force, no new creation, takes place; only a communication of disturbed condition from one molecule to another is transpiring, and this process continues until an equilibrium between all the molecules is obtained. All particles of matter are subject to natural affections, or to the energies which nature employs in her processes. The single molecules will remain at rest toward each other so long as they are equally affected or in an equally sensitive condition. But as soon as their affections differ in degree, then a more or less violent endeavor takes place to restore their former equality. The principles of nature are essentially democratic and founded on even justice.

13. All exhibitions of force result from a disturbance of equilibrium. This is equally true in a cosmical as it is in a terrestrial sense. The equilibrium of the universe is preserved by the constant tendency of gravitation to correct regular and irregular perturbations, and thus to maintain, not the equilibrium which attends rest, but which is the result of well-balanced motion. Nature knows no absolute rest—motion is universal. Where rest appears, it is only comparative. The motion of our planet and its life is supported by the light of the sun, which is a never-failing source of energy. Without the sun's influence, the play of all other energies would cease—stagnation and death would result. Owing to that constant flow of energy which is poured upon the planets by the central luminary, their molecular equilibrium is kept uninterruptedly disturbed. Not only is the earth's individual rotation maintained, but it is driven around the luminar center of gravitation, thereby proving that its center of life is not within itself, but outside of it. And by the same energy all minor planetary processes are sustained, more or less remotely, because they are all effects of the central cause.

14. The sun, by virtue of its greater mass, is positive opposite the planet, which, as the lesser quantity, is negative. And since matter is equivalent to force, the sun represents an overwhelming energy compared to the planetary energies. This immense difference constitutes a never-failing source of disturbance to planetary rest. In their mutual endeavor to restore rest and equilibrium, the sun is kept revolving around itself, and the planets are driven on in their swift race; and since equilibrium of rest can never be restored, an equilibrium of endless motion is the result.

15. Force is matter in motion. Mechanical motion proceeds from an outer cause, and is only communicated outwardly—that is, mechanically. If an iron ball is set in motion by powder, that motion is simply communicated or imparted by the expansive force of the gases which have been dynamically evolved by the process of combustion. That dynamical process was initiated by a match or by friction or percussion. The powder explosion takes place because of the disturbed equilibrium of the particles of powder. In a steam engine the elastic power of steam acts upon the piston, and its motion is communicated to various kinds of machinery. The dynamical motion is converted into mechanical motion, and the latter again expends itself in friction, and friction again produces heat and electricity. It does not matter how a force is produced or started, none can ever be lost. When a force is expended apparently, it has only been communicated to some neighboring matter, or has been converted into some other mode of motion. Nor can a new force be produced by any process whatever. When a weight falls ten feet, it has thereby produced a certain amount of mechanical action. But to restore the previous condition of things, the weight has to be raised again to the point of starting, and the same amount of force is expended. When steam is raised as a motive power, it is done through the agency of heat. But heat is the result of a chemical process by which no atom is destroyed; only old combinations are destroyed and new ones are formed. Now this process of combustion is attended by the phenomena of heat, and this heat is converted into mechanical action, and at last back again into heat and electricity. The heat which raised the steam was evolved by that oxydizing process in which carbon and oxygen unite and form carbonic acid. The principle of heat manifests itself through the vehicle of matter, its combinations and decompositions. The principle is universal and invariable. Matter is subject to certain mathematical evolutions, governed by certain laws on mathematical formulas, and these formulas have materialized and expressed themselves in certain fixed motions or modes of action, and these modes are known as heat, light, electricity, magnetism, etc. Now since these material actions of well-defined mathematical principles can only take place by means of matter which is constituted accordingly, and to suit the action, or whose consolidation is fixed by that very action of the spiritual or scientific principle, it follows as a matter of course that the quantity of existing forces is just as invariable as is matter itself.

[To be Continued.]

MR. MUSHET AND THE BESSEMER PROCESS.

Wrought iron is the pure metal, cast iron contains 2 to 4 per cent of carbon, and steel from $\frac{3}{4}$ to $1\frac{3}{4}$ per cent of carbon. Wrought iron is made by laboriously extracting the carbon from cast iron, and steel is made by restoring a portion of the carbon to wrought iron.

Bessemer's first plan was to remove just enough of the carbon from cast iron to leave it in the state of steel, and thus avoid the round about process of changing the metal first to wrought iron. It is well known that if carbon at a high temperature is brought into contact with free oxygen, the two elements combine to form either carbonic oxide or carbonic acid, and that both of these substances are gases. As one-fifth of the atmospheric air is free oxygen, Bessemer conceived the simple plan of blowing atmospheric air through molten cast iron, to burn out a portion of the carbon contained in the iron.

Mr. Bessemer, on trying his plan, found that it was exceedingly difficult to stop the combustion of the carbon at just the point to leave the metal in a state of steel, and the method now adopted is to continue the operation until the carbon is wholly consumed, and the molten cast iron is added to this wrought iron in such proportion that the mixture will contain the requisite quantity of carbon to form steel.

But there is difficulty in stopping even at the point where the carbon is all consumed. Oxygen has a very strong affinity for iron, especially when the iron is heated, and if on entering the mass it finds no carbon with which to combine, it enters into combination with the iron, forming oxide of iron. Oxide of iron is a brittle substance, and if it is scattered through a mass of iron it destroys the tenacity and value of the metal. It is manifest that the combination of oxygen with the iron is almost certain to commence before the whole of the carbon is consumed, as an atom of oxygen entering the molten mass might meet with an atom of iron before it encountered the last atom of carbon.

This fatal difficulty in the process was effectually overcome by a suggestion of Mr. Mushet, a suggestion which has made the Bessemer process a practical industry. The last number of the *London Engineer*, in a leading editorial on the subject, says:—

"Oxygen, in combining with carbon, produces a gaseous compound, only one-half heavier then air itself; and hence this compound must, of necessity, rise to the surface. But in combining with iron oxygen forms a heavy metallic compound, which is quite as likely to remain secreted in the pores of the melted mass as to float—for in no case can it escape into the air. That this compound is not formed from the first application of the blast is more than probable, because when, by a lucky hit decarburization has been stopped at the right point for steel, the product is much less red short than when the process is continued until all the carbon is exhausted. But however this may be, the danger of burning the iron before it is fully converted remains as distinctly as ever. Mr. Mushet saw it with the eye of a practised metallurgist, and almost as soon as he could have known of Mr. Bessemer's discovery, to wit, in September, 1856, he patented the remedy. His reasoning was rapid and conclusive. There was the oxygen secreted in the iron, and it must be got out. How? By presenting to it a metal more oxidizable than iron—a metal whose own affinity for oxygen would de-oxydize the iron. Such a metal is manganese; and the best vehicle for manganese, in this case, is spathic iron, or spiegeleisen. The best proof of the value of this addition is the fact that it was only after it was made that Bessemer metal took a recognized position in the market.

"Strangely enough, a discovery at once so important has brought no rewards to its author. Mr. Mushet's affairs were in the hands of trustees, and in 1859, three years after the reading of Mr. Bessemer's memorable paper at the Cheltenham meeting of the British Association, his process was looked upon as so hopelessly worthless that his trustees would not pay the £50 stamp to keep alive the patent for a discovery upon which the present value of the Bessemer process mainly depends. So it lapsed, and Mr. Bessemer lost no time in turning his opportunity to account, and how well he has done so is proved by the fact, which he takes no pains to conceal, that his present income from royalties exceeds £100,000 per annum! His royalties are £1 per ton for ingots for rails, £2 a ton for ingots for axles, &c., and £3 per ton for ingots for a higher quality of steel; and these are strictlyenforced against the largest concerns in the land. Even the London and North-Western Railway Company obtain no discount, and if the Ebbw Vale Company have done so it has been in the form of a sale of Martien's curious patent to Mr. Bessemer for £30,000—Martien having parted with it for £500."

Mechanical Progress.

Under this head the Hartford *Daily Post* pays the following compliment to the SCIENTIFIC AMERICAN:—

"We cannot do a greater service to machinists than to call their attention to a series of illustrated articles on 'Turning Tools' just published in the SCIENTIFIC AMERICAN. They are evidently from the pen of a practical workman, and are invaluable, not only for the accurate illustration, but for truly practical suggestions they contain. Probably on no one thing are machinists so disagreeing as on the proper shape of turning tools, and the proper use to which the varying kinds are applied. Some seldom use a 'bossing' or 'diamond point,' roughing off the work with a 'side tool.' It is an expensive and awkward use of a tool intended and adapted mainly to 'squaring up.' But in grinding tools the master mechanic submits to many annoyances in consequence of the shiftless habit of men who satisfy themselves with touching the point or cutting edge alone upon the stone. By a little care and time spent in properly grinding a tool, much labor is saved the forger, and a tool can be used up to the stock and still kept in shape without once dressing if managed with some degree of care and intelligence. A 'side tool' after being once finished should never be ground on the vertical cutting face. The top and edges alone should be ground and the latter more than the former. Many workmen grind the cutting point of a diamond tool until the back angles are much the highest and then the tool 'gnaws' the work instead of cutting it. A slight rounding of the cutting angle or face of the 'diamond point' will ensure smoother work and retain the edge much longer than where the corner is left a perfect angle. In finishing a shaft for a fit, or for a bearing, the slovenly habit of using the file ought to be entirely abandoned. A water polish with a 'square nosed' tool insures perfect rotundity and gives a better surface than the file and emery can. No more should be removed by this finishing cut than will just obliterate the marks of the bossing tool and leave a good surface. In the article referred to in the SCIENTIFIC AMERICAN the writer approves of the use of 'swan neck or spring tools.' We think their use of doubtful utility. No dependence can be placed upon securing perfect roundness or truth unless the material turned is perfectly homogeneous, a condition which the best iron, and even steel, will rarely fulfill. Instead of allowing for springiness in either the work or the tool, we believe that absolute stiffness and rigidity are indispensable to making a good job. Another bad habit among careless workmen is the use of turning tools indiscriminately on the lathe and the planer. While turning tools must have considerable 'rake,' the planer tools are forged nearly at right angles with the stock."

[By referring to page 34, current volume of the SCIENTIFIC AMERICAN, our readers will see precisely what we said about the use of spring tools.—EDS.

THE King of Siam, whose full name is "Phra Bart Somdetch Phra Paramenpe Maha Monghui Phra Chaum Kiow Chow Yu Hua," recently celebrated his sixtieth birthday, the ceremonies being of the most gorgeous character.